CEMENT AND LIME MANUFACTURE

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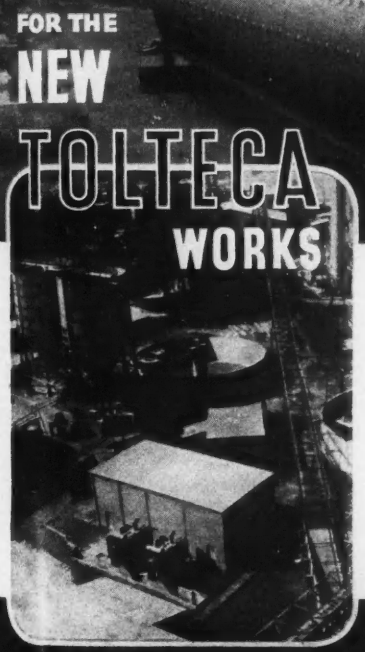

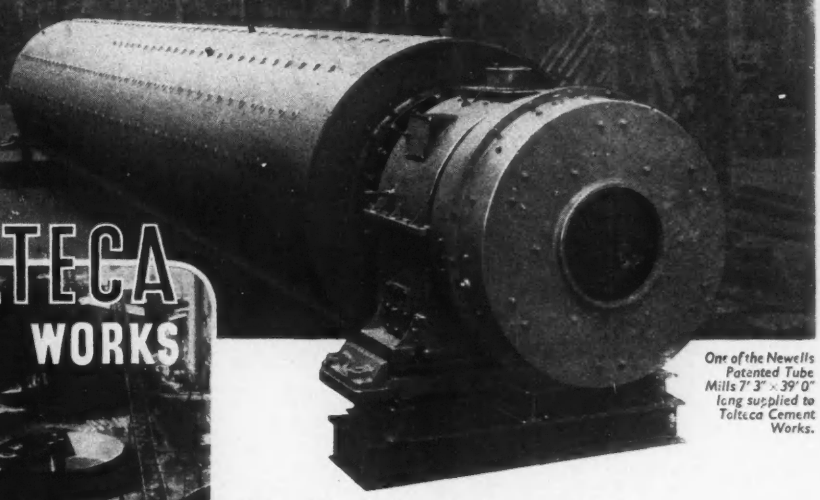

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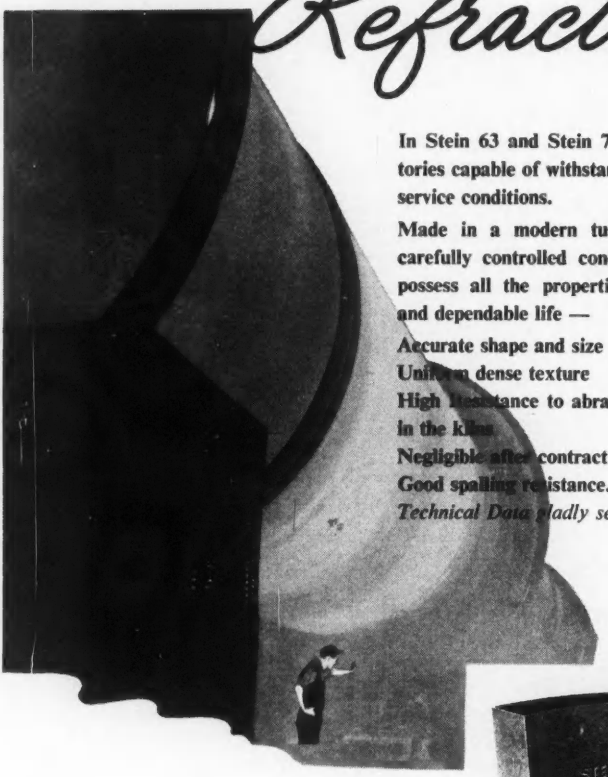

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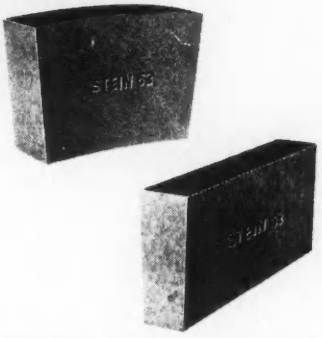

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The publishers regret that the issue of this number has been delayed by a disturbance in the London printing trade.

New Cement Works at La Tolteca, Mexico.

A MEXICAN company, La Tolteca Compania de Cemento Portland, S.A., formed with British and Mexican capital, has recently completed the construction of a new two-kiln wet-process plant in Mexico. The works is situated at an altitude of about 6,500 ft. and is fifty miles from Mexico City on the main Mexico City—Cuidad Juarez Mexican National railway. For reasons of economy it was decided to build the new works alongside the old dry-process plant which has been in operation for forty years. Thus the old quarry, cement storage silos, packing plant, sidings, and workshops, can be used but generally the new plant is on a new site. The existing works staff carried out the erection of the new equipment under the direction of Mr. L. Elek (Factories Manager) and Mr. H. B. Stewart (General Superintendent). Mr. W. R. Marshall (from England) was in charge of the erection of much of the British-made equipment, except the kilns which were under the supervision of the makers, and Mr. M. H. Torres, Works Superintendent, was responsible for all the electrical equipment. The plant was designed by the Chief Engineer and staff of the Associated Portland Cement Manufacturers, Ltd. (the owners of the British-owned shares) after the general arrangement had been decided by the Tolteca Company.

It was decided that two 350-ft. rotary kilns be installed with provision for two more later, and that sufficient space be left for extra ancillary equipment. Where possible, equipment such as conveyors and elevators which are not easily duplicated was designed to have sufficient capacity for four kilns unless the cost was considered to be too high and it was arranged that all equipment other than the kilns and their ancillary machines should work 44 hours a week if possible.

Flow Of Materials.

The flow diagram (*Fig.* 3) shows the equipment and the individual capacities.

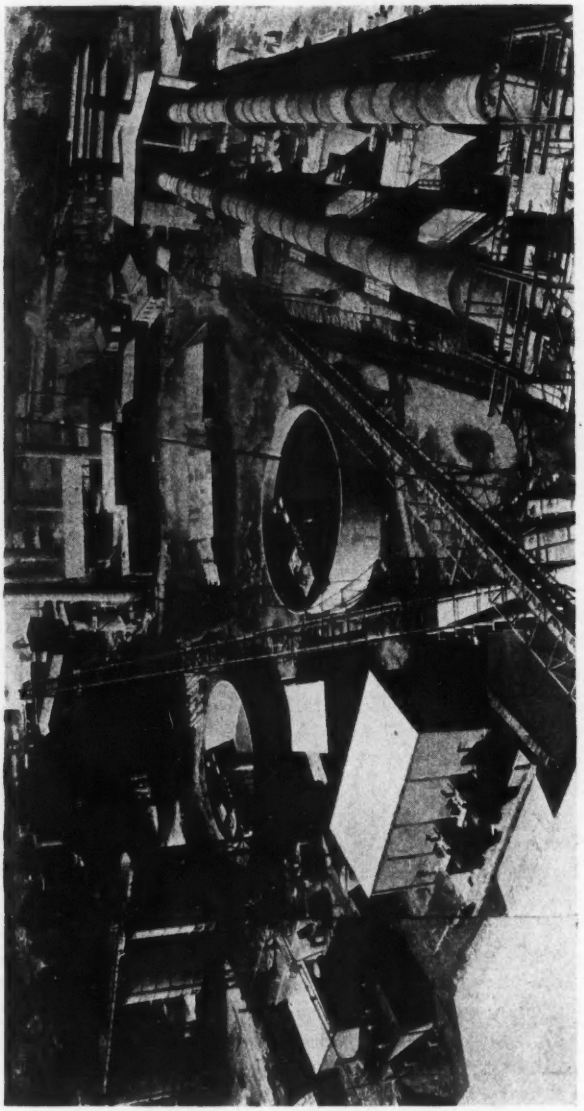


Fig. 1.—View from Chimney During Construction.

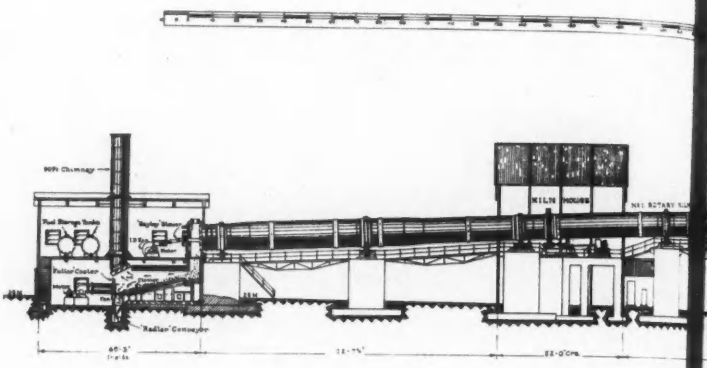
The limestone is quarried by blasting the face and loading by means of face shovels into Euclid end-tipping wagons operated by diesel engines. The primary and secondary stages of crushing are carried out in the quarry by means of one 42-in. McCully gyratory crusher followed by two 4¼-ft. Symons cone crushers. The crushed material is then taken by belt-conveyor to a 600-tons hopper (*Fig.* 4). Discharge ports are arranged to feed 13-tons Euclid bottom-discharge diesel vehicles which transport the stone about three miles along a concrete road to the works. The limestone is delivered into a 65-tons hopper at road level, from whence it is conveyed by belt-conveyor over the Tula river to the 3rd-stage crusher building, where two 4-ft. short-head Symons cone crushers reduce the stone to minus ½ in. and a belt-conveyor takes the material to a store building. The store contains the crushed limestone, the clinker, and gypsum. Extending the full length of the building is a 4-tons overhead electric grab-crane which can deal with all of these materials.

A clay deposit about one-third of a mile to the west of the works is worked by means of a Sauerman 2½-cu. yd. drag-scraper. This delivers clay to a hopper at ground level from whence it is discharged by an apron-feeder to a belt-conveyor. This belt discharges the clay, which contains a proportion of " huesco " (hard clay) and other foreign matter, on to a slow-running picking-belt travelling on a gantry. The material picked from the belt by hand drops through a chute to small railway wagons below. The clay is discharged to a 16-ft. diameter wash-mill, where it is made into slip with a water content of about 65 per cent. From the wash-mill the slip is pumped by two 12-in. by 15-in. three-throw reciprocating pumps (one as standby) through a 6-in. pipeline to a 66-ft. diameter reinforced concrete tank, fitted with stirrers, at the works. Two centrifugal pumps feed the slip to a ring-main from the storage tank, and the overflow from this main is returned to the tank. From suitable points pipes are arranged to feed the wet mills, the quantity being controlled by the rate of flow through plates with orifices calibrated to work in conjunction with pressure gauges.

The limestone, clinker, and gypsum store is arranged so that these materials can be extracted from below the floor on to variable-speed belt-feeders which in turn discharge on to conveyor-belts feeding the two wet mills. The jet of clay-slip is directed on to the limestone entering the chute leading to the wet mill.

Two 800-h.p. compound mills produce the cement slurry, which passes over vibrating screens at the discharge ends of the mills, in open launders, to two 12-in. by 15-in. three-throw ram pumps (one is a standby). These pumps deliver to any of three steel mixing-tanks of 23,500 cu. ft. capacity each, which are air agitated. The corrected mixture flows by gravity from these tanks into either one of two 66-ft. diameter reinforced concrete tanks similar to the clay-storage tank mentioned previously. Two similar 12-in. by 15-in. ram pumps (one a standby) are used for supplying the spoon-feeders which in turn feed the kilns, the overflow returning to the storage tanks.

Two 350-ft. rotary kilns with enlarged burning zones are supported on six roller beds on reinforced concrete piers (*Fig.* 2). The hot clinker from the kilns



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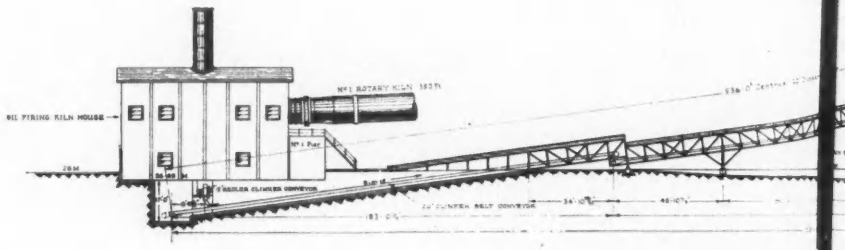
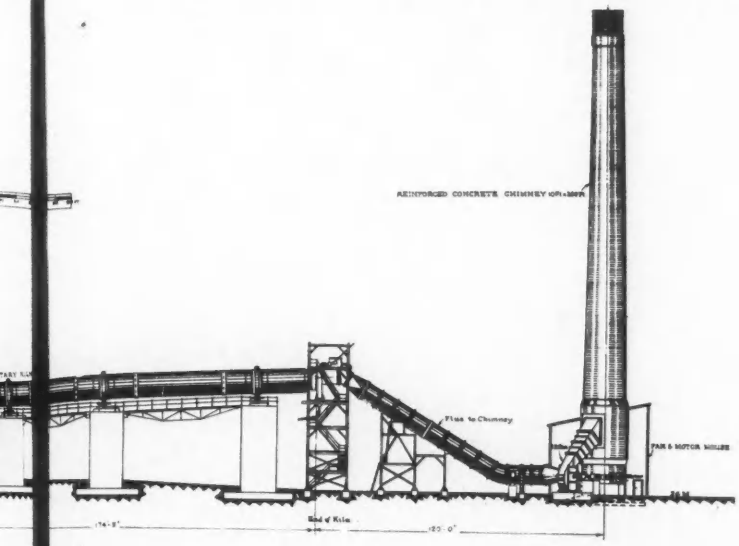
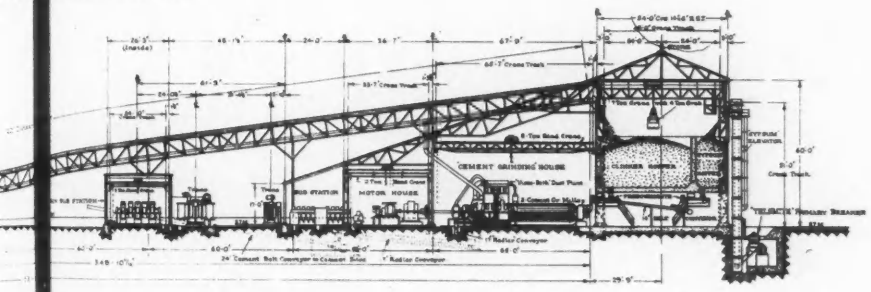


SECTION THROUGH CEMENT-GRI

Fig. 2.—The Kilns a



ELEVATION OF KILN PLANT.



MILL HOUSE, SUB-STATIONS, ETC.

ment-grinding Plant.

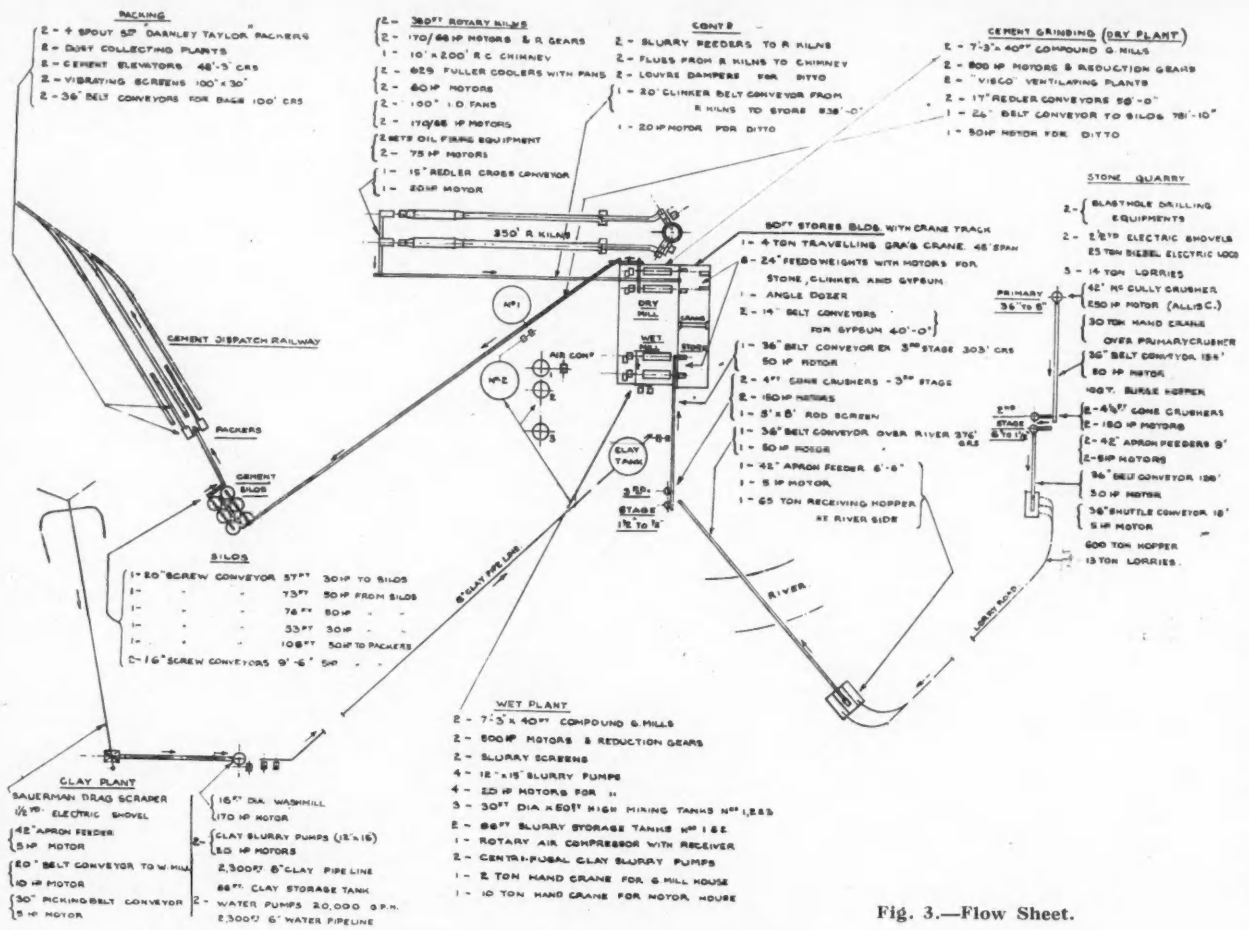

PACKING
2 - 4 SPOUT 52" DARNLEY TAYLOR PACKERS
2 - DUST COLLECTING PLANTS
2 - CEMENT ELEVATORS 48'-3" CRS
2 - VIBRATING SCREENS 100" x 30"
2 - 36" BELT CONVEYORS FOR BAGS 100' CRS
2 - 380FT ROTARY KILNS
2 - 170/66 HP MOTORS & R. GEARS
1 - 10' x 200' R.C. CHIMNEY
2 - 629 FULLER COOLERS WITH FANS
2 - 40 HP MOTORS
2 - 100" I.D. FANS
2 - 170/66 HP MOTORS
2 METZ OIL FIRING EQUIPMENT
2 - 75 HP MOTORS
1 - 15" REDLER CROSS CONVEYOR
1 - 20HP MOTOR
CONT'D
2 - SLURRY FEEDERS TO R. KILNS
2 - FLUES FROM R. KILNS TO CHIMNEY
2 - LOUVRE DAMPERS FOR DITTO
1 - 20' CLINKER BELT CONVEYOR FROM R. KILNS TO STORE 838'-0"
1 - 20 HP MOTOR FOR DITTO
CEMENT GRINDING (DRY PLANT)
2 - 7'-3" x 40FT COMPOUND G. MILLS
2 - 800 HP MOTORS & REDUCTION GEARS
8 - "VISCO" VENTILAPING PLANTS
2 - 17" REDLER CONVEYORS 58'-0"
1 - 24" BELT CONVEYOR TO SILOS 781'-10"
1 - 50HP MOTOR FOR DITTO
350' R. KILNS
80FT STORES SILOS WITH CRANE TRACK
1 - 4 TON TRAVELLING GRAB CRANE 46' SPAN
8 - 24" FEEDO WEIGHTS WITH MOTORS FOR STONE, CLINKER AND GYPSUM
1 - ANGLE DOZER
2 - 14" BELT CONVEYORS FOR GYPSUM 40'-0"
1 - 36" BELT CONVEYOR EX 3RD STAGE 303' CRS
50 HP MOTOR
2 - 4FT CONE CRUSHERS - 3RD STAGE
2 - 150 HP MOTORS
1 - 5' x 8' ROD SCREEN
1 - 36" BELT CONVEYOR OVER RIVER 376' CRS
1 - 50 HP MOTOR
1 - 42" APRON FEEDER 6'-0"
1 - 5 HP MOTOR
1 - 65 TON RECEIVING HOPPER EX RIVER SIDE
STONE QUARRY
2 - BLASTHOLE DRILLING EQUIPMENTS
2 - 2½YD ELECTRIC SHOVELS
25 TON DIESEL ELECTRIC LOCO
5 - 14 TON LORRIES
PRIMARY 36" TO 8"
42" Mc CULLY CRUSHER
250 HP MOTOR (ALLIS C.)
30 TON HAND CRANE OVER PRIMARY CRUSHER
36" BELT CONVEYOR 156'
50 HP MOTOR
100T. SURGE HOPPER
2ND STAGE 8" TO 1½"
2 - 4½FT CONE CRUSHERS
2 - 150 HP MOTORS
2 - 42" APRON FEEDERS 9'
2 - 5HP MOTORS
36" BELT CONVEYOR 128'
50 HP MOTOR
36" SHUTTLE CONVEYOR 18'
5 HP MOTOR
600 TON HOPPER
13 TON LORRIES.
CEMENT DISPATCH RAILWAY
PACKERS
CEMENT SILOS
No 1
No 2
DRY MILL
WET MILL
STORE
AIR COMP
CLAY TANK
3RD STAGE 1½" To ½"
6" CLAY PIPE LINE
RIVER
A LORRY ROAD
SILOS
1 - 20" SCREW CONVEYOR 57FT 30HP TO SILOS
1 - " " 73FT 50HP FROM SILOS
1 - " " 76FT 50HP " "
1 - " " 33FT 30HP " "
1 - " " 108FT 50HP TO PACKERS
2 - 16" SCREW CONVEYORS 9'-6" 5HP " "
CLAY PLANT
SAUERMAN DRAG SCRAPER
1½YD ELECTRIC SHOVEL
42" APRON FEEDER
5 HP MOTOR
20" BELT CONVEYOR TO W. MILL
10 HP MOTOR
30" PICKING BELT CONVEYOR
5 HP MOTOR
16FT DIA. WASHMILL
170 HP MOTOR
2 - CLAY SLURRY PUMPS (12" x 16")
250 HP MOTORS
2,300FT 8" CLAY PIPE LINE
66FT. CLAY STORAGE TANK
2 - WATER PUMPS 20,000 G.P.M.
2,300FT 6" WATER PIPELINE
WET PLANT
2 - 7'-3" x 40FT COMPOUND G. MILLS
2 - 800 HP MOTORS & REDUCTION GEARS
2 - SLURRY SCREENS
4 - 12" x 15" SLURRY PUMPS
4 - 250 HP MOTORS FOR "
3 - 30FT DIA x 60FT HIGH MIXING TANKS Nos 1,2&3
2 - 86FT SLURRY STORAGE TANKS Nos 1 & 2
1 - ROTARY AIR COMPRESSOR WITH RECEIVER
2 - CENTRIFUGAL CLAY SLURRY PUMPS
1 - 2 TON HAND CRANE FOR G. MILL HOUSE
1 - 10 TON HAND CRANE FOR MOTOR HOUSE

Fig. 3.—Flow Sheet.

discharges into two Fuller coolers. The flue gases are carried away from the back ends of the kilns in steel flues, which are lagged or brick-lined. The flues carry the gases to ground level and thence through louvre-dampers to two induced-draught fans and finally to the 200-ft. reinforced concrete chimney. Access between the kiln piers is provided by steel walkways. The drive (*Fig.* 2) is the only part of the kiln which is covered. The cooled clinker is delivered to a Redler conveyor which discharges on to a 20-in. belt-conveyor which is carried to the top of the clinker store on a steel gantry and walkway. Gypsum is fed into the store by an elevator which in turn is fed from a Telsmith crusher. The kilns are oil fired. The firing plant consists of storage tanks heated by a boiler. Pumps transfer the fuel oil to the vaporisers, which have induced-draught fans to supply the air. The firing-pipes are led to the front end of the kiln.

Clinker and gypsum are extracted through the floor by four variable-speed belt-feeders, two for gypsum and two for clinker, which discharge into the chutes feeding two 800-h.p. compound grinding mills. The cement mills are ventilated by a Visco dust plant which changes the air twice a minute. The plant is lagged and provided with an electric heater to prevent the moisture-laden air from setting the dust inside the filter. The cement is transported from the mills by two Redler conveyors, in series, to a 24-in. belt-conveyor on a gantry to the top of the existing cement storage silos. This conveyor discharges into a single screw-conveyor travelling along the top of the silos, and supplies the silos by means of breeches chutes controlled by slides.

The discharge from the bottom of the silos is by a pair of screw-conveyors along the centre-line of the two rows of silos. These discharge into a short transverse screw-conveyor, and thence to a long screw-conveyor which takes the cement to the packing plant. The cement is here separated into two streams by adjusting a slide to allow half of the cement to fall through an opening in the screw-casing. These streams of cement are now elevated to the top of the packing building in slow-speed central-discharge elevators which feed two surge-hoppers after the cement has passed over vibrating screens to remove any nibs. Each surge-hopper is directly above a 4-spout "Modern" packing machine, and the overflow from these hoppers is fed into a bin below. So long as a constant level of cement is maintained in the surge-bunkers, a uniform output from the packers is obtained; this level is maintained by having a continuous overflow of cement from the surge-hopper above the packers. Return screws take the overflow from the hopper back into the system. It will be seen that if the discharge from the silos is set slightly in excess of requirements it will take a considerable time for the overflow bin to fill. The system is not automatic, but it is simple and inexpensive. Each packing machine feeds a flat belt-conveyor 36 in. wide travelling along the rail-loading platforms, and scraper-ploughs can be placed anywhere along the belt for the removal of the bags of cement.

General.

All the major reinforced concrete buildings and structures were designed by Messrs. Oscar Faber & Partners. All drives up to 50 h.p. are worm reduction-

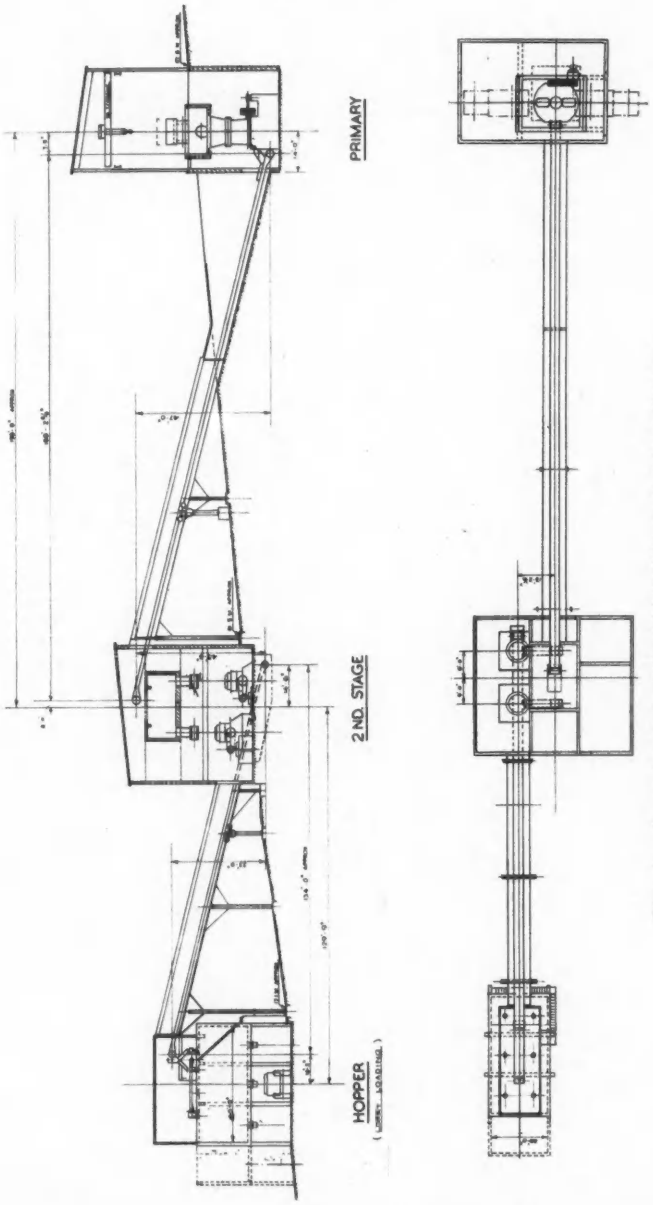


Fig. 4.—Arrangement of Crushing Plant at Stone Quarry.

gears manufactured by David Brown & Sons (Huddersfield), Ltd., with the exception of the 5-h.p. drives which were supplied by Stone Wallwork, Ltd. Standardisation throughout the plant was arrived at by having as few different sizes as possible. All apron-feeders are 42 in. wide and manufactured by Barry, Henry & Cook, Ltd., while the variable-speed drives were supplied by Stone Wallwork, Ltd. All reciprocating pumps are identical 12-in. by 15-in., 3-throw machines manufactured by Ernest Newell & Co., Ltd., and are driven at 10·5 r.p.m. through gears. All conveyors were, unless otherwise stated, manufactured by Barry, Henry & Cook, Ltd., while the gantries with walkways on which they are carried were supplied by Lambhill Ironworks, Ltd. The ease with which this equipment was erected is ascribed to the numbering of every part and each number being shown on the working drawings. Furthermore, complete structures were painted different colours so that they were easily grouped on the site before erection. Economy was effected by sheeting-in only on the prevailing-wind side of the walkways on all gantries except those on the cement and clinker conveyors. All the hand-operated overhead travelling cranes were manufactured by the Vaughan Crane Co., Ltd. The portable electrical testing equipment was supplied by Evershed & Vignoles, Ltd., and the end-couplings for the cables in the quarry and all emergency stop-buttons by Geo. Ellison, Ltd.

The Quarry.

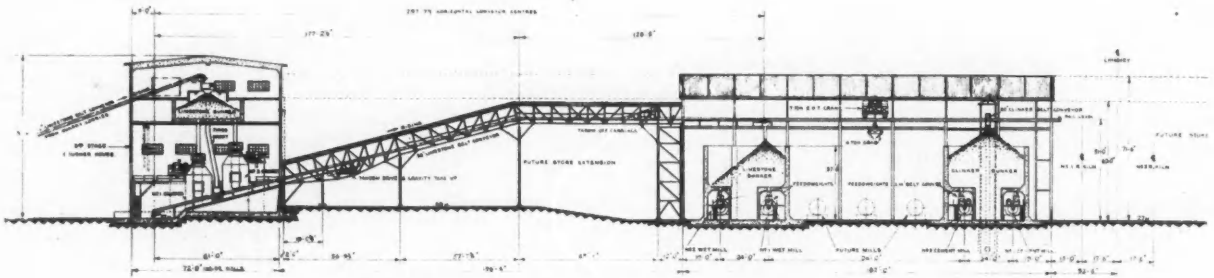
The quarry is about three miles from the works. Bucyrus-Erie type 27T drills are used in conjunction with Bucyrus-Erie 54B face shovels of 2½-cu. yd. bucket capacity. The drills and shovels are electrically operated, the shovels being fitted with 125-h.p. induction motors at 3000 volts driving Ward Leonard sets.

Power to the quarry is supplied by the Mexican Light & Power Co. at 22,000 volts and it is transformed through a 1250-k.v.a. transformer to 3000 volts. A 250-k.v.a. 3000—440-volt transformer supplies the low-tension power. The electrical equipment comprises metal-clad and truck-type switchgear, lighting transformer, distribution switchboards, interlocking relays, motors and controllers. The gate-end circuit breakers for the quarry were supplied by Switchgear & Cowans, Ltd. The face shovels load end-tipping Euclid type 27FD diesel-engine operated trucks of 14-tons capacity. Only three of these were initially provided as the distance was short, the primary and secondary crushers being in the quarry.

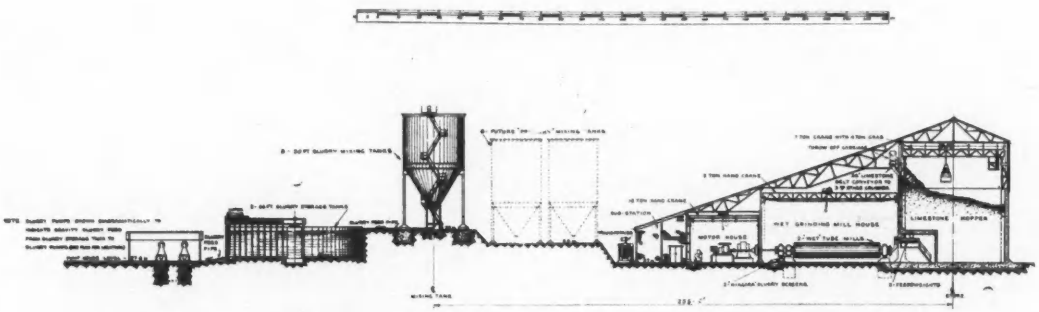
Crushing Plant.

Primary and secondary crushing are carried out at the quarry in separate buildings (*Fig.* 4). The primary crusher is a 42-in. Allis-Chalmers McCully gyratory machine, of 700 tons per hour capacity, driven through a V-rope drive by a 250-h.p., 735-r.p.m., 3000-volt Allis-Chalmers slip-ring motor. This machine is in a reinforced concrete building and has a 30-tons hand-operated overhead crane, made by Herbert Morris, Ltd., for maintenance purposes.

The lorries supply a small rectangular hopper at ground level above the mouth of the crusher, and the crushed stone minus 6 in. is delivered directly on to a



SECTION THROUGH STORE AND THIRD-STAGE CRUSHER HOUSE.



SECTION THROUGH WET GRINDING MILLS, MOTOR HOUSE, SLURRY STORAGE TANK, ETC.

Fig. 5.

36-in. belt-conveyor. The length of the belt is 195 ft. between centres and slopes at 17 deg. 25 minutes; it is fitted with a 50-h.p. drive, operates at 250 ft. per minute, and is carried above ground by a gantry fitted with walkways on one side. The stone is delivered to a reinforced concrete surge-hopper at the top of the second-stage crusher building, from which it is extracted by two 42-in. apron-feeders each feeding a 4¼-cu. ft. Symons cone crusher supplied by the Nordberg Manufacturing Company. Each machine is driven through a V-rope drive by a 170-h.p. motor at 3000 volts and 592 r.p.m. The maintenance of the crushers is assisted by having 10-tons chain-blocks on overhead runways which can lift out the moving parts, and there is room for putting the "dolly" down.

Stone minus 1½ in. is delivered from these two machines on to a 36-in. belt-conveyor at 138-ft. centres and 14 deg. slope, and is carried on a gantry above ground to the top of the 600-tons reinforced concrete lorry-loading hopper. The speed of the belt is 250 ft. per minute, and it is driven by a 30-h.p. motor through a worm reduction-gear. In *Fig.* 4 it is seen that this conveyor discharges through a breeches chute on to a 36-in. shuttle belt-conveyor so that any of the three compartments in the hopper can be filled. This conveyor is operated by a 5-h.p. motor and reduction gear and is moved by hand. Three discharge-gate chutes below fill 13-tons capacity bottom-discharge diesel lorries with trailers supplied by the Euclid Road Machinery Co. Good road access is provided to facilitate the loading of lorries. Stone minus 1½ in. is discharged from the lorries into an underground hopper on the quarry side of the Tula river, as shown at the bottom right-hand corner of the plan of the new works which it is intended to give in our next number.

A 42-in. apron-feeder extracts the stone and delivers it to a 36-in. belt-conveyor which is carried on a gantry across the river to the top of the third-stage crusher building. The centres of the drums are 376 ft. 6 in. and the rise 14 deg.; the conveyor has a speed of 250 ft. per minute and is driven by a 50-h.p. motor. The belt delivers stone to a Symons 8 ft. by 5 ft. rod deck-screen operated by a 10-h.p. motor which screens out material of ½ in. and below. The screen is mounted above a limestone bunker (through the centre of which the fines chute passes), and discharges on to the 36 in. belt-conveyor below the third-stage crusher (*Fig.* 5). The limestone bunker choke-feeds, by means of chutes, two 4-ft. short-head Symons cone crushers which discharge minus ½ in. stone directly on to a 36-in. belt. This belt-conveyor is 303 ft. 6 in. between drums, slopes at 14½ deg., and is carried in a gantry to the top of the limestone, gypsum, and clinker store. Discharge from the belt is by means of a moving tripper-carriage. These two crushers are operated by 170-h.p. motors similar to those used for the second-stage crushing by V-rope drives. For the maintenance of the crushers, there are 5-ton blocks on runways above the machines, and space is available for getting out the "dolly" and lowering it to the floor.

The crushing and conveying plant are capable of dealing with the output of four kilns, except that two additional third-stage crushers will have to be installed on foundations already provided in the crusher house, and possibly a 60-h.p. motor will be necessary to drive the belt-conveyor from the riverside hopper.

Fig. 6.—View Looking South During Construction.

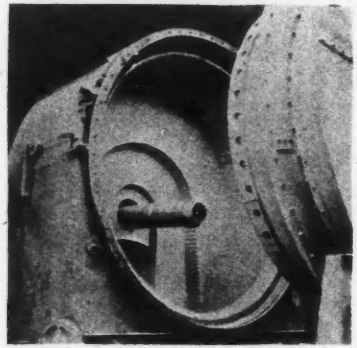


Fig. 7.—Kiln Hood (Firing End) and Burner Nozzle in Course of Erection.

Fig. 8.—Cement Silos and Conveyor Gantry from Grinding Mills.

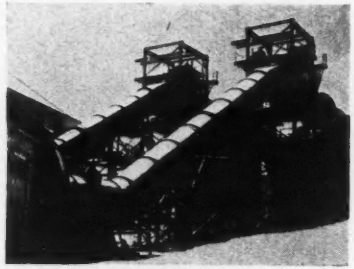


Fig. 9.—Kiln Flue Ducts.

The Store Building.

The store is 182 ft. long, and the general construction and arrangement are shown in *Figs.* 2 and 5. It will be seen that this building, which is of reinforced concrete, can be extended at either end in the future.

The elevated feed-platforms to the wet and dry mills have the material discharging on to them from the belt-conveyors above, but this can be supplemented by the 4-tons grab-capacity overhead travelling electric crane, of 48-ft. span, supplied by J. H. Carruthers & Co., Ltd. The gantry extends the full length of the building and is 51 ft. high, and it can be extended into the open if open stock-piles are required. The gypsum is fed from a tipping wagon at ground level into a size 10A Telsmith primary breaker, from whence it is delivered to the store by an elevator (*Fig.* 2). From the drawings it is seen that the elevated feed-platforms discharge on to 24-in. " Feedoweights " each 8 ft. 7 in. long supplied by the Merrick Scale Manufacturing Co. Each wet mill has its own feeder, whereas each cement mill has one pair of feeders (one for gypsum and one for clinker). The clinker and gypsum feeders feed a common 14-in. belt-conveyor. Each of these belts is driven by a 2-h.p. motor. For the clinker and stone " Feedoweights," the speed of the belt can be varied between 4 · 8 ft. per minute to 14 · 4 ft. per minute, whereas the speed of the gypsum feeders can be varied between 0·24 and 0·72 ft. per minute.

Figs. 6 to 8 give several views of the works during construction.

(*To be continued*).

Imports of Cement in Persia.

IT is reported that the total value of Portland cement imported in Persia was £120,000 for the year ended March 20, 1949, including imports from the United Kingdom, £44,000 ; U.S.A., £2,000 ; Russia, £39,000 ; India, £9,000 ; Pakistan, £8,000 ; Belgium, £6,000. The quota for the year ended March 20, 1951, is £330,000.

During the past year the United Kingdom has obtained most of the business for coloured Portland cement. Of the business for ordinary Portland cement the United Kingdom has obtained about 35 per cent., the remainder being imported from Japan, Germany, Czechoslovakia, Poland, Russia, France, and Italy. H.M. Commercial Counsellor at Tehran reports that the higher price which United Kingdom cement was previously able to command is now obtainable only for private schemes for which architects are employed, as they appreciate its quality. Government departments are bound to accept the cheapest offers, which have recently come from Japan and Poland. Russia has offered competitive prices for cement delivered in Persia. Recently acceptance by Japan of an offer of 139s. per short ton for 15,000 tons has been reported.

The Structure of Hydrated Pozzolana Cement.

ITALIAN RESEARCH.

AT the Institute of Applied Chemistry at Cagliari University, Professor B. Tavasci has continued his work on pozzolana and Portland cements, and some results have been published (*La Chim. e l'Ind.*, 1949, 31 (11) pp. 392–398), of which the following is an abstract. In the hydration of pozzolanas various changes occur which it is well to study separately, the most important being clinker changes which have been examined microscopically in thin layers after few days standing and also metallographically after a few years. The various forms observed, some of which are illustrated by micro-photographs, are described under the designations B, C, D, E. The first is mainly basic hydrosilicate of lime ; the second, in the form of very fine needles, could not be definitely identified but was somewhat analogous, from its refraction index, etc., to the compound $3CaO.Al_2O_3.18H_2O$, or possibly to those acicular forms observed under the microscope during the first stages of hydration with excess of water ; form D appeared to be a mixture of aluminates and ferrites ; E was derived not so much from the clinker as from other changes in the cement as a whole. All the tests have been made with Segni pozzolanas.

Samples were prepared with 30 per cent. water content, and were kept for 28 days immersed in water. The ratio of clinker to pozzolana was 2 : 1. The average composition of the clinker was SiO_2, 21·1 per cent. ; Al_2O_3, 6·4 per cent. ; Fe_2O_3, 3·2 per cent. ; CaO, 65·7 per cent. Styrol resin was used for absorption and in order that this should be as complete as possible the absorbed or saturated fragments were only a few millimetres thick. Care was taken to avoid the risk of carbonising, and this was reduced to less than 0·5 mm. Eighteen micro-photographs show the results of micrographic examination with magnifications from 200 to 850. All of these were pozzolana cements except two which were Portland. The water content was 30 per cent. or 35 per cent., and the solutions used for reflection were 0·5 per cent. HCl in alcohol and 1 per cent. iodine in alcohol. The samples were seventeen years old, except in cases where the lime/pozzolana ratio was 15 : 85 which were seven years old.

The general structure shown at a magnification of 200 reveals clinker grains still unchanged, pozzolana grains, lime, and voids filled with styrol resin. These are mostly bonded by the matrix coloured brown by the reagent (dilute HCl). The exposure was from 5 to 10 seconds. Portions or edges that had to be exposed to the atmosphere were slightly carbonated.

The various constituents or groups thereof are discussed in detail. The clinker is partly alitic and partly belitic, the former predominating and the latter seldom appearing in its characteristic form and sometimes showing cracks. Celite also appears to be present in appreciable amount. There is some evidence of free lime, and also of hydrated lime similar to that indicated by Elsner v. Gronow[7] and by Guttmann and Gille[8], and of clinker corrosion.

The Segni type of pozzolana has been fully described[5] together with certain corrosion and other changes[3, 4, 6]. It is suggested that the reagent used has little effect and that the principal changes are due to action of the clinker present. Three kinds of changes are described, depending mainly on the depth and extent thereof, including in one case the presence of a zeolite of the cabasite class.

In the hydration of the clinker there is an appreciable formation of crystalline calcium hydrate, indicated by using alcoholic iodine solution or 50 per cent. alcohol alone. It is noted that beside some free lime or hydrate the hydrolytic lime is almost negligible in many cases, though sometimes the indicator shows dark patches of " lime of hydrolysis " depending evidently on the proportion of water present.

The matrix (massa di fondo) is generally of fine texture and of granular appearance, but there are differences in the degree to which the various parts are affected by the indicating reagent, depending largely on basicity. In some of the illustrations shown, especially around the alite zone (A), there are groupings or bundles of appreciable thickness in which the granular structure is absent. These more nearly correspond with the isotrope constituent B, formed from calcium hydrosilicate, and they are mostly accompanied by fragments of celite. These formations are compared with those in Portland cement, especially the needle-like forms containing, or consisting of, ferric compounds. Certain annular manifestations were at first puzzling, but on further examination it was decided they were veins or channels filled with styrol resin when preparing the samples for the microscope. They were held to be characteristic of pozzolana cements, distinguishing these from Portland cements.

The next point considered is the chemical action of pozzolana. Such action is generally admitted with lime and pozzolana cements, but with pozzolana cements strictly so called it is sometimes disputed. In a mixture of clinker and pozzolana three different kinds of action have been noted, namely (a) almost complete disappearance of the hydrolytic lime (calce d'idrolisi), (b) corrosion, sometimes very marked, of the pozzolana grains, and (c) formation of a matrix or base body of granular structure similar to that of lime and pozzolana. All these indicate chemical activity between the pozzolana and clinker (hydrated). The suggestion sometimes made that the pozzolana serves merely to split off the hydrolytic lime is an over-simplification. It has been found in fact that this splitting off is by no means complete, and the action of the pozzolana on the hydrosilicates formed from the clinker can by no means be overlooked. These hydrosilicates are not only to be found in the " bundles " around the alite ; clinker forms the principal part of the cement and its chief hydration product should evidently permeate the whole mass. The granular structure of the mass implies the presence of silica, and also alumina derivable from the pozzolana ; and these, owing to better distribution, are in close contact with the hydrosilicates which in turn will more readily yield lime the higher their ratio of $CaO : SiO_2$.

Silica and combined oxides of Al and Fe (R) were determined by the Florentin method, giving the following results :

	Mixture (pasta)	*Clinker*	*Pozzolana*	*Cement* (calculated)
SiO_2 sol.	14·80	21·10	1·80	13·19 (12·65 + 0·54)
R_2O_3	8·76	9·54	11·94	9·33 (5·75 + 3·58)

In considering these results it is necessary to remember that in the mixture is the combined water of hydration. On heating to 550 deg. C. the mixture lost 19·3 per cent. in weight, and the pozzolana lost 6·23 per cent. (the normal loss on heating of pozzolana is 9·28 per cent.)

From these and other analytical data in respect to SiO_2 and R_2O_3 contents in the initial cement, in the clinker, and in the pozzolana it is concluded that there is marked solubility of the pozzolana in the mixture. More particularly its combining action with lime, generally admitted in the case of lime and pozzolana mortars, is confirmed also with cement mixtures of the kind described, being shown both microscopically and by chemical analysis through increase both in soluble silica content and, to a less degree, in soluble iron-aluminium oxides content.

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Coarse-ground Cement for Experimental Road.

IN order to get information on the relative durability of concrete roads in which coarse and fine Portland cements are used, the State Highway Commission of Kansas, U.S.A., is to use coarsely ground cement for about 18 miles of a new concrete road 24 miles long carrying considerable traffic including heavy vehicles. The coarsely ground cement will be made as nearly as possible to match the Portland cement used in the district thirty years ago, while the remainder will be Type 1 finely ground cement as made to-day. The experiment is being made as a result of an investigation made in the years 1940 to 1944, when an inspection of 1270 miles of concrete roads showed that those laid before the year 1930 were more satisfactory than those laid since ; it was found that the older roads, although cracks had appeared, were sound and more durable. The specifications for the whole of the road are exactly the same except for the fineness of the cement.

Low-heat Cement for a Dam in Tasmania.

THE new Clark dam at Butler's Gorge, Tasmania, is 200 ft. high and 1,000 ft. long, and has a maximum thickness of about 80 ft. The heat of hydration was kept low by using a modified Portland cement in which the heat generated at seven days did not exceed 70 calories per gramme and at 28 days 80 calories. Because of the risk that the dolerite aggregate might react with the cement, the alkali content of the cement was limited to 0·6 per cent. The cement, of which about 40,000 tons were used, was delivered to the site in bags which were split and rumbled mechanically and the contents deposited in a 750-tons steel silo. It is thought that the loss of cement due to this method did not exceed ½ per cent. compared with up to 2 per cent. in the ordinary method of emptying bags. Bulk transport was not used because of the cost of returning the empty containers a distance of 240 miles, partly by road and partly by rail.

The first specification was for a low-heat cement with the properties given in *Table* I. Early laboratory tests indicated the importance of long and thorough curing of the concrete. The possibility of delayed setting during cold weather was also realised. Tests repeated in 1948 with cement stored in sealed tins since 1946 gave results similar to those in *Table* II, with one notable exception, namely the strengths of low-heat cement concrete at 28 and 90 days were 1600 lb. and

TABLE I.—PROPERTIES OF CEMENTS USED AT CLARK DAM.

Type of Cement		C_3S	C_2S	C_3S plus C_2S	C_3A	C_3A plus C_4AF	Free lime (CaO)	Magnesia	Heat of Hydration. Calories per gramme		Setting Time. Hours	
									7 Days	28 Days	Initial	Final
Low-heat cement	Specification .. *Max.*	40	65	80	7·0	22	1·25	4·0	60	70	—	12
	Min.	—	35	—	1·0	—	—	—	—	—	1	—
	Average of 3 tests ..	26·6	47·4	74·0	3·7	19·8	0·4	1·4	51·5	69·3	2½	4¼
Modified Cement (2 parts L.H., 1 part Ordinary)	Average of 7 tests ..	35·0	40	75·0	4·46	19·1	0·6	1·7	60·6	73·5	2¼	3⅔
	Specification .. *Max.*	45·0	—	—	6·0	25·0	1·25	4·0	70	80	—	12
	Min.	33·0	—	—	1·0	—	—	—	—	—	1	—
	Average of 12 tests (1947)	38·7	36·5	75·2	2·4	18·5	0·9	1·4	60·7	72·9	2¾	4
	Average of 12 tests (1948)	41·2	34·4	75·6	2·56	18·5	0·5	1·5	62·9	74·6	2	3¾
	Average of 9 tests (1949)	38·8	37·8	76·6	2·8	17·0	0·4	1·9	60·9	73·2	2⅔	3⅔

TABLE II.—COMPRESSIVE STRENGTH OF CONCRETE WITH ABOUT 10 PER CENT. OF CEMENT.

Cement	Compressive Strength lb. per sq. in.			
	7 days	28 days	90 days	1 year
Low Heat 1946	800	1600	1800	—
Blended Cement (1 part L.H., 1 part O) 1946	1700	3500	5800	7500
Blended Cement (2 parts L.H., 1 part O) 1947	1200	3100	5800	—
Modified Cement May-Sept., 1947..	1200	2800	5400	7000
Modified Cement June-Dec., 1948	1400	3200	6300	7800
Modified Cement Jan.-Mar., 1949..	1600	3600	6400	—

1800 lb. per square inch in 1946 and 1550 lb. and 4700 lb. per square inch in 1948. The improvement was probably due to better curing. Blended cement (low-heat and ordinary in equal parts) was used in 1946, and two parts of low-heat to one of ordinary cement early in 1947. Results attained with this blend were satisfactory and were the basis of the modified cement used. The comparative compressive strengths of concrete mixed in the batching and mixing plant on the site, and moulded and cured in the laboratory, are shown in *Table* II.

Concrete cores, 6-in. in diameter, cut from the dam and containing blended low-heat and ordinary cements in equal parts, had average compressive strengths of 6000 lb. per square inch at 90 days, compared with 4000 lb. per square inch in the laboratory tests of the same concrete.

The specific-surface of the cement as determined by the Banks-Pecover air-permeability apparatus gave an average of 3400 sq. cm. per gramme compared with an average of 1850 sq. cm. per gramme by the Wagner turbidimeter.

The Packing and Transport of Cement.

IN this journal for January, 1950, we gave an abstract of an article from " Zement-Kalk-Gips " on the transport of loose cement. The original article (in the German language) has now been published with much additional matter as a booklet entitled " Packen, Verladen, und Transport von Zement," by E. Plassmann, E. Rubland, and O. Faber. (Weisbaden : Bauverlag G.M.B. H. 1949. Price 2 D.M.) It describes and illustrates a number of methods of handling cement in bags and transporting cement in bulk by road and rail taken from the practice of the Dyckerhoff Portland-Zementwerke A.G.

The Effect on Concrete of Freezing and Thawing.

RESEARCH Paper No. 2000 of the U.S. National Bureau of Standards is entitled "Volume Changes Observed in Small Concrete Cylinders during Freezing and Thawing using a Mercury Displacement Dilatometer." The following is a summary of the paper as given by the author, Mr. Rudolph C. Valor, Jr.

The results presented are confined to representative volume-temperature relationships for small cylindrical specimens cast from concrete of the same mixture (plain and modified by the addition of an air-entraining agent) and made with one brand of normal Portland cement and river aggregate. The moisture condition of the specimens ranged from air-dry to vacuum-saturated. Most tests were made on specimens in a state of partial saturation during various curing periods. These specimens, when tested, contained from 65 to more than 85 per cent. of the total water that they contained upon being oven-dried, evacuated, and

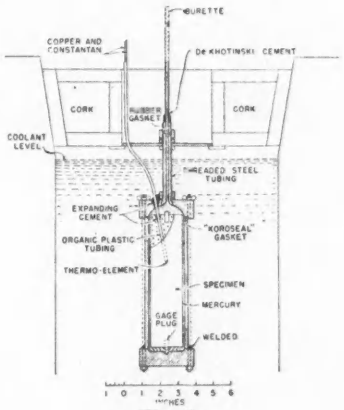

Fig. 1.

resaturated following the freezing and thawing tests. The freezing and thawing cycles varied between temperatures of + 40 deg. F. to — 20 deg. F., including a slow cycle which required 32 hours and a fast cycle which required one hour for completion.

The volume changes for all specimens tested in the air-dry condition were directly proportional to changes in temperature and independent of the rate of temperature change. The slopes of the volume-temperature relationships obtained were measures of the thermal coefficients of expansion. The volume changes for the partially-saturated specimens were generally not independent of the rate of temperature change, and showed departures from a uniform volume-temperature relationship such as that described for the air-dry specimens. These departures were believed to be effects of the conversion of water to ice (or ice to water) within the pores of the specimens. The immediate effect of the freezing of water

was a distension, which appeared to be directly related to the rate of cooling in those cases in which supercooling was minimized or absent.

Secondary effects of freezing were shrinkage and relaxation, which consisted of contractions in addition to the normal thermal contraction of the solid volume. The specimens usually showed a permanent residual expansion at the completion of a cycle. The residual expansions for repeated cycles were cumulative. During slow cooling the pore-water in a specimen was apparently supercooled before it froze. The amount of supercooling diminished in succeeding repetitions of the slow cycle, except that, when the specimen was maintained unfrozen for a sufficient time after any cycle, supercooling in the following slow cycle was again pronounced. There was no evidence of supercooling during the fast cycle.

Vacuum-saturated specimens subjected to one slow cycle showed distensions upon freezing, and residual expansions at the end of the cycle more than 30 times as great as the corresponding volume changes in partially-saturated specimens similarly tested. According to accepted criteria for soundness, these specimens would have failed during one cycle of freezing and thawing.

The dilatometer is shown in *Fig. 1.* The vertical cylindrical chamber was constructed of 0·15-in.-thick seamless mild-steel tube 2·05 in. in internal diameter and 7·25 in. in height. The top and bottom were formed of 1-in. steel plate. The bottom plate was machined to fit the tubes and then welded into place. The steel cover was machined to fit the top of the cylinder, and the inner surface of the cover was funnel-shaped to facilitate the removal of air entrapped during the liquid filling process. The apex of the inverted funnel opened into a $\frac{5}{8}$-in. outside-diameter threaded steel tube, to the top end of which a glass burette assembly was attached. The cover was attached to the cylinder by means of four $\frac{1}{4}$-in. bolts which extended through the bottom plate, and was secured by wing-nuts. A compressible organic plastic gasket 0·002-in. thick was placed between the top of the cylinder and the cover to prevent loss of mercury.

Measuring pipettes were used as dilatometer burettes. The tips were broken off and the straight-bore stems were cemented into short lengths of threaded steel tube to form interchangeable and detachable assemblies. A thin hard-rubber gasket separated the tube at the bottom of the burette from the tube that formed a part of the dilatometer cover. Pipettes of 1-ml., 2-ml., and 5-ml. capacity were used. For most tests, the 1-ml. size was satisfactory, but for tests of vacuum-saturated specimens it was necessary to use the 5-ml. size. Only those pipettes for which the mean error of marking was less than 1 per cent. were used. Readings were estimated to 0·001 ml. for the 1-ml. and 2-ml. pipettes. Therefore, changes in volume as small as 0·0003 per cent. could be discerned for specimens with bulk volumes ranging between 335 ml. and 340 ml.

The Cement Industry in Britain.

A STATEMENT issued by the Cement Makers' Federation points out that during the first half of the year 1950 deliveries of cement in the home market at 3,900,000 tons, or about 330,000 tons more than in the first half of 1949, were the highest on record. The Minister of Works had said in Parliament that the cement industry had produced a great deal more cement than was anticipated would be required. At the beginning of each year the Ministry of Works indicated how much cement it was anticipated would be required for the home market and how much it was considered would be available for export.

For the year 1950 the Government under-estimated the amount of cement that would be required for the home market, but during the first half of 1950 150,000 tons more were delivered to the home market than the Government originally estimated would be required.

Except for a very small part this output had been achieved with pre-war plant. Before the war no cement shortage ever occurred because the industry was always able to plan production ahead of demand and to build new factories when and where required. In those days it took less than 18 months to build a new factory, but then there were no difficulties about supplies nor were there so many controls; the industry was free to plan the work and get on with it. In the year 1945 the cement industry submitted to the Ministry of Works plans for the construction of three new factories and the reconstruction or enlargement of six others, designed to produce an additional 1,570,000 tons of cement per annum. If they could have been built as quickly as before the war, they would have been in operation in 1947, but at the end of five years only some 300,000 tons of new capacity per annum were in operation. Shortages of materials after the war were bound to cause delays, but these were made far worse by the multiplication of unco-ordinated controls and consents which defeated orderly planning at the site and in the shops making the machinery. The numerous public and official inquiries under the Town and Country Planning Act, Government policies and changes of policies on the location of industry and capital expenditure, the number of building licences required, the failure to co-ordinate these licences with authorisations for raw material and supplies, and above all the delays and vacillations about steel authorisations, had imposed endless obstructions, frustrations, and expense on the industry. That was why factories that used to take 18 months to construct had taken more than four years. The industry was pressing on as fast as it was allowed to, and it was hoped that its capacity would be materially increased in 1950 and 1951. Last year about 1,800,000 tons of cement were exported, but it could not be expected that this would be maintained in future because new works were being erected in countries in which cement was now imported from Great Britain.

Cement Plant for Spain.

BY the terms of a new trade agreement between Denmark and Spain, cement-making plant of the value of 8,000,000 kroner is to be exported from Denmark to Spain.

State-owned Cement Works in Turkey.

THE Minister of State Enterprises in Turkey stated recently that the Ankara Cement Works would be amongst the first factories to be made available to Turkish or foreign private ownership, but that it would be some months before an arrangement for the sale or leasing of the works could be announced.

Cement Production in North Africa.

IT is reported that the demand for cement in French North Africa is now about 1,100,000 tons a year. The production in Algeria is 980,000 tons a year, and it is anticipated that in the year 1951 the production in this territory (Algeria, Morocco, and Tunisia) will be sufficient to meet the demand. In the year 1938 the amount of cement produced in these three countries was 300,000 tons a year.

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